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WATER QUALITY STUDIES OF LOWER AND MIDDLE GREEN BAY 1938 - 1977

by

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FOREWORD

The Great Lakes National Program Office (GLNPO) of the United States Environmental Protection Agency was established in Region V, Chicago to focus attention on the significant and complex natural resource represented by the Great Lakes.

GLNPO implements a multi-media environmental management program drawing on a wide range of expertise represented by Universities, private firms, State, Federal, and Canadian Governmental Agencies and the International Joint Commission. The goal of the GLNPO program is to develop programs, practices and technology necessary for a better understanding of the Great Lakes Basin Ecosystem and to eliminate or reduce to the maximum extent practicable the discharge of pollutants into the Great Lakes system. The Office also coordinates U.S. actions in fulfillment of the Agreement between Canada and the United States of America on Great Lakes Water Quality of 1978.

This study was supported by a GLNPO grant to the Wisconsin Department of Natural Resources to gather data on southern Green Bay and make it available through the medium of a computerized data base.

ABSTRACT

Research with quantitative water quality data from Green Bay was located and evaluated by objective criteria. Data from "high priority" studies were entered into Environmental Protection Agency computer systems (chemical data in STORET and biological data in BIOSTORET). A summary of the data stored is presented.

Using this data base, changes in Green Bay water quality were examined, but made difficult by deficiencies and inconsistencies in the different researchers sampling locations, frequencies, and methods. A sampling network is proposed that would correct the deficiencies and efficiently monitor water quality conditions in Green Bay.

The data stored in the computer systems and the proposed sampling network provide background information for future research on Green Bay water quality.

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SECTION 1

INTRODUCTION

The decline of the water quality of Green Bay and the subsequent aesthetic and economic losses has been a matter of concern for many years. This concern has spurred a great deal of research on the bay, but nowhere has the cream of this work been gathered and made available in one place.

The purpose of this project was to store as much of the data as possible in the appropriate Environmental Protection Agency computer systems (chemical data in STORET, and biological data in BIOSTORET). The bulk of the results of this project are not in the pages of this report., but are stored in these systems. It is hoped the work accomplished and described here can be used by subsequent investigators as a quantitative reference. For a qualitative reference, The Green Bay Watershed, Past/Present/Future (Bertrand et al., 1976) gives an excellent review of conclusions of most of the studies computerized.

Studies of Green Bay were identified which dealt quantitatively with parameters of interest to researchers working on the evaluation of water quality. Within this group of studies, further restrictions were made and the studies most appropriate and valuable for long term computer storage were chosen. The data from these studies was then processed and entered into the STORET and BIOSTORET computer systems. Since some of these studies were either unpublished or unavailable for decades, the increased availability should be valuable.

This new and composite data base was examined for strengths and weaknesses. Based on this examination, suggestions for future monitoring that will make better use of the data already available on changes in water quality of Green Bay have been provided.

SECTION 2

CONCLUSION

The data added to the STORET/BIOSTORET data base documents the changes in water quality in Green Bay from 1938 to 1977. An examination of the research data reveals varied approaches to sampling water quality parameters. By examining these approaches, deficiencies in the data base were detected and rectified in the proposed sampling network. Considerations of station location, sampling frequency, needed information, and monetary limitations were prime factors in assembling the proposed network.

The value of this project is primarily for future researchers. If the proposed sampling network is followed and data stored in the computer system is used for comparison to sampled data, the results will have greater value to the scientific community. Thus strengthened, the data base will also be more useful to regulatory and management agencies.

SECTION 3

RESEARCH DATA EVALUATED FOR COMPUTER STORAGE

The first step of the project was to locate the sources and secure the release of data. Once a data set was secured and the methods of collection and analysis checked, the study was evaluated according to the importance of its inclusion relative to other studies. A number of "high priority" studies were collected which represented a data base of sufficient breadth and depth to be included in the computer systems.

The criteria for choosing the studies to computerize were 1) purpose of the study and subsequent nature and extensiveness of the data, 2) reliability of the principal investigator, 3) lucidity of the data, and 4) degree of support of the data by previous and subsequent research. All studies considered for inclusion in the STORET and BIOSTORET systems are listed (Table 1) with the studies finally computerized followed by the system's name in parentheses.

Studies not computerized had one or more of the following characteristics: 1) qualitatively valuable data, but quantitatively less precise than is generally considered appropriate for inclusion in computer storage, 2) questionable techniques, 3) inconsistent research data as compared to reliable, relevant data from other sources, 4) few data points for the amount of processing work involved, 5) impossibility of obtaining release of unpublished or unprocessed data from the investigators, and 6) studies unavailable in time for processing.

Although the evaluation and ranking of the studies is a subjective procedure, attempts were made to objectify it by fixed criteria.

TABLE 1. STUDIES CONSIDERED FOR STORAGE IN STORET AND BIOSTORET SYSTEMS

Adams, M.S. AND W. Stone. 1973. Field studies on photosynthesis of Cladophora glomerata (Chlorophyta) in Green Bay, Lake Michigan. Ecology 54(4)853-862. (STORET)

Allen, H.E. 1966. Seasonal variation of nitrogen, phosphorus and chlorophyll a in Lake Michigan and Green Bay, 1965, Contrib. 471 Great Lakes Fisheries Lab. Bureau of Sport Fisheries and Wildlife: Tech. Pap. 70, 23 pp. (STORET)

Balch, R.F., K.M. Mackenthum, W.M. Van Horn and T.F. Wisniewski. 1956. Biological studies of the Fox River and Green Bay, 1955-1956. Wisconsin State Comm. Water Poll. Bull. WP102, 74 pp. mimeo.

Bott, T.L. 1968. Ecology of Clostridium botulinum type E. Unpublished Ph.D. dissertation, University of Wisconsin, 85 pp.

Gannon, J.E. 1972. Contributions to the ecology of zooplankton crustacea of Lake Michigan and Green Bay. Unpublished Ph.D. dissertation, University of Wisconsin, 257 pp.

Holland, R.E. 1969. Seasonal fluctuations of Lake Michigan diatoms. Limnol. and Oceanogr. 4:423-436.

____________. and L.W. Claflin. 1975. Horizontal distribution of planktonic diatoms in Green Bay, mid-July 1970. Limnol. and Oceanogr. 20:365-378.

Howlett, G.F. 1974. The rooted aquatic vegetation of Green Bay with reference to environmental change. M.S. thesis, Syracuse University.

Howmiller, R.P. 1971. The benthic macrofauna of Green Bay, Lake Michigan. Unpublished Ph.D. dissertation, University of Wisconsin. 225 pp. (BIOSTORET)

____________. and A.M. Beeton. 1972. Report on the cruise of the R/V NEESKAY in central Lake Michigan and Green Bay, 8-14 July, 1971. Center for Great Lake Studies, University of Wisconsin, Spec. Rept. 13, 70 pp.

Lee, K.W. and A.I. Goldsby. 1974. Physical and biological interrelationships related to Green Bay Metropolitan sewage discharge plume in a complex coastal zone in lower Green Bay and the Fox River. Report to the Green Bay Metropolitan Sewage District. 75 pp.

Leland, H.V. and N.F. Shimp. 1974. Distribution of selected trace metals in southern Lake Michigan and lower Green Bay. University of Illinois Water Resources Center, Research Rept. 84, 28 pp.

Maase, M.H. 1978. Chironomidae of Green Bay. Personal communication.

Neustadter, R. 1976. Unpublished report on the Fox River. WDNR.

____________. 1977. Unpublished chemical data on the water and sediments of Green Bay. (STORET)

Sager, P. and J. Wiersma. 1972. Nutrient discharges to Green Bay, Lake Michigan from the lower Fox River. Proc. 15th Conf. Great Lakes Research. I.A.G.L.R. pp. 132-148. (STORET)

__________________. 1975. Phosphorus sources for lower Green Bay, Lake Michigan. J. Water Poll. Control Fed. 47:504-514. (STORET)

__________________. 1977. Trophic status - lower Green Bay 1976-1977. Rept. to the Fox Valley Water Quality Planning Agency. 59 pp. (STORET)

Schraufnagel, F.H., L.A. Lueschow, G. Karl, L.A. Montie, J. Lissack and J.R. McKersie. 1968. Report on an investigation of the pollution in the lower Fox River and Green Bay made during 1966 and 1967. WDNR, Internal Report. 47 pp.

Schwartz, L.J., A.I. Goldsby and J. Wiersma. 1976. Biological, chemical and physical impacts of sewage effluent discharges in lower Green Bay. Rept. to Green Bay Metropolitan Sewage District. 88 pp.

Sridharan, N. 1972. Aqueous environmental chemistry of phosphorus in lower Green Bay, Wisconsin. Ph.D. dissertation, water chemistry, University of Wisconsin. (STORET)

Stewart, W.D.P., T. Mague, G.P. Fitzgerald and R.H. Burris. 1971. Nitrogenase activity in Wisconsin lakes of differing degrees of eutrophication. New Phytol. 70:497-509.

Surber, E.W. and H.L. Cooley. 1952. Bottom fauna studies of Green Bay, Wisconsin in relation to pollution. U.S. Public Health Service and Wisconsin State Comm. Water Pollution. 77 pp. mimeo. (BIOSTORET)

U.S. Department of Interior. 1967. Green Bay Pilot Study. Fed. Water Poll. Cont. Adm. Great Lakes Region, Chicago, Illinois. 34 pp.

U.S. Army Corps of Engineers. 1969. Green Bay Pilot Study. Appendix A9 in dredging and water quality problems in the Great Lakes. Summary report, Buffalo district.

U.S. Army Corps of Engineers. 1975. Maintenance dredging and contained disposal of dredge materials at Green Bay harbor, Wisconsin. Draft Environmental Impact Statement, Chicago District. 28 pp.

Vanderhoef, L.N., B. Dana, D. Enerich, and R.M. Burris. 1972. Acetylene reduction in relation to levels of phosphate and fixed nitrogen in Green Bay. New Phytol. 71:1097-1105. (STORET and BIOSTORET)

Vanderhoef, L.N, C.Y. Huang, R. Musil and J. Williams. 1974. Nitrogen fixation (acetylene reduction) by phytoplankton in Green Bay, Lake Michigan in relation to nutrient concentrations. Limnol. and Oceanogr. 19:119-125. (STORET and BIOSTORET)

Veith, G.D. 1975. Baseline concentrations of polychlorinated biphenyls and DDT in Lake Michigan fish, 1971.' Pesticides Monitoring J. 9(1):21-29. (BIOSTORET)

Wisconsin Public Service Corporation. 1974. Effects of Wisconsin's Public Service Corporation's Pulliam power plant on lower Green Bay, January 1973-December 1973. 483 pp. (STORET and BIOSTORET)

Wisconsin Public Service Corporation. 1976. J.P. Pulliam power plant 316(a) demonstration type 1: Absence of prior appreciable harm. 378 pp. (STORET and BIOSTORET)

Wisconsin State Committee on Water Pollution. 1939. Investigation of the pollution of the Fox and East Rivers and Green Bay in the vicinity of the city of Green Bay. Madison, Wisconsin. 242 pp. (STORET)

Yaguchi, E.M., B.J. Walker and J.S. Marshall. 1974. Plutonium distribution in Lake Michigan biota. Proc. 17th Conf. Great Lakes Res., pp. 150-157. I.A.G.L.R.

SECTION 4

ANALYSIS OF STUDIES COMPUTERIZED

It is only necessary to glance through a few of the studies computerized (summarized in table 2, A-L) to see how difficult an attempt to generate a holistic picture of the Green Bay data base can be. Some problems encountered are: 1) Sample values are not comparable because investigators used different techniques to test for the same parameter. 2) Researchers, thinking of their studies as self contained units rather than in a historical context, were often quite casual in identifying the exact locations of their stations. When in doubt whether to combine two stations or to keep the data sets separate, the latter was done. This deprives the data base of continuity. One excellent data set used three overlapping, but not identical, sets of stations (Vanderhoef, 1972, 1974). 3) Many areas of lower Green Bay have stations every few hundred feet, while other areas have been virtually ignored (Figure 1).

During the 1970's there was intensive sampling of Green Bay (Figure 2). The data base for this period is extensive, despite the low efficiency of gathering data. Since 1975, controls on effluents entering Green Bay have been introduced and enforced, but the sampling effort has declined. Improvement in the water quality is not as easily documented because of this. There is little water chemistry data in 1976 and 1977 from north of Long Tail Point and there has been no large scale biological sampling since 1975.

It is clear from the data that Green Bay was already experiencing a serious decline in water quality by 1938. The Burrowing Mayfly (Hexagenia), once so common in the area it was a pest at emergence, was already declining in numbers. By 1952 Hexagenia had nearly disappeared, and even tolerant species such as Sludgeworms (Plesiopora) were being reduced in number by the pollution near the mouth of the Fox River. By 1969 the mouth of the Fox River was a biological desert for invertebrates. Heavy blooms of diatom species characteristic of highly eutrophic waters were no longer confined to inner Green Bay, but extended to the Brown County line. More extensive analysis of the biological data is not presently feasible due to the problems with the BIOSTORET system (see appendix for elaboration of the problems).

Comparisons of the water chemistry data can be made for the more extensively sampled parameters. The comparisons reveal short term fluctuations in lower Green Bay values due, in part, to changing levels of the Fox River (a major source of pollutants) and long term trends indicating improved water quality of lower Green Bay. Trends in middle Green Bay are not as distinct and can be interpreted variously.

Figures 4 thru 8 represent the data which showed trends over the periods of the study. For purposes of this analysis, the bay is divided into 10 regions as shown in Figure 3. The graphs show mean values for years where at least 5 measurements were available. Lower Green Bay, regions 1-7, is represented by solid lines on the graphs. Regions 8-10, represented by dashed lines, divide middle Green Bay.

Orthophosphate levels (Figure 4) show fluctuations relating to Fox River flow values (the lower the flow rate, the greater the concentration of nutrients entering Green Bay), but the dramatic drop between the 1971-72 and 1973-74 periods is due (in part) to phosphorus controls. No return to the high values of 1971-72 occurs in 1975-77 when the flow values again drop. Since little total phosphorus data from before 1973 is stored in STORET, an expected drop in total phosphorus between 1972 and 1973 cannot be detected, and only a gradual increase from 1973 to 1977 due to decreasing Fox River flows is shown (Figure 5). Both total phosphorus and orthophosphate values are generally highest near the Fox River mouth, decrease as the distance from the Fox River increases, and due to the counterclockwise currents in Green Bay are usually higher in eastern Green Bay at comparable distances from the Fox River as compared to western Green Bay.

Secchi disc depths for lower Green Bay indicate a relationship to Fox River flow rates (Figure 6). Increased flow rates result in lower concentrations of suspended particulate matter and less extensive algal blooms, causing greater clarity in lower Green Bay. Values generally increased as the distance from the Fox River mouth increased.

Dissolved oxygen values (Figure 7) are usually lower in eastern Green Bay away from the Fox River (Regions 5,7,9). During the winter the Fox River has high amounts of dissolved oxygen, but also large amounts of organic compounds. As the organic load moves into eastern Green Bay, its oxygen demand reduces oxygen levels in ice-covered Green Bay. An exception to this pattern occured in the winter of 1976-77 when ice conditions and low Fox River flow rates resulted in low dissolved oxygen values over most of lower Green Bay. There is a trend towards increased dissolved oxygen in summer (Figure 8) indicating the positive effect of effluent controls. The 1977 values for region 1 (near the Fox River mouth) are almost double the values from 1939.

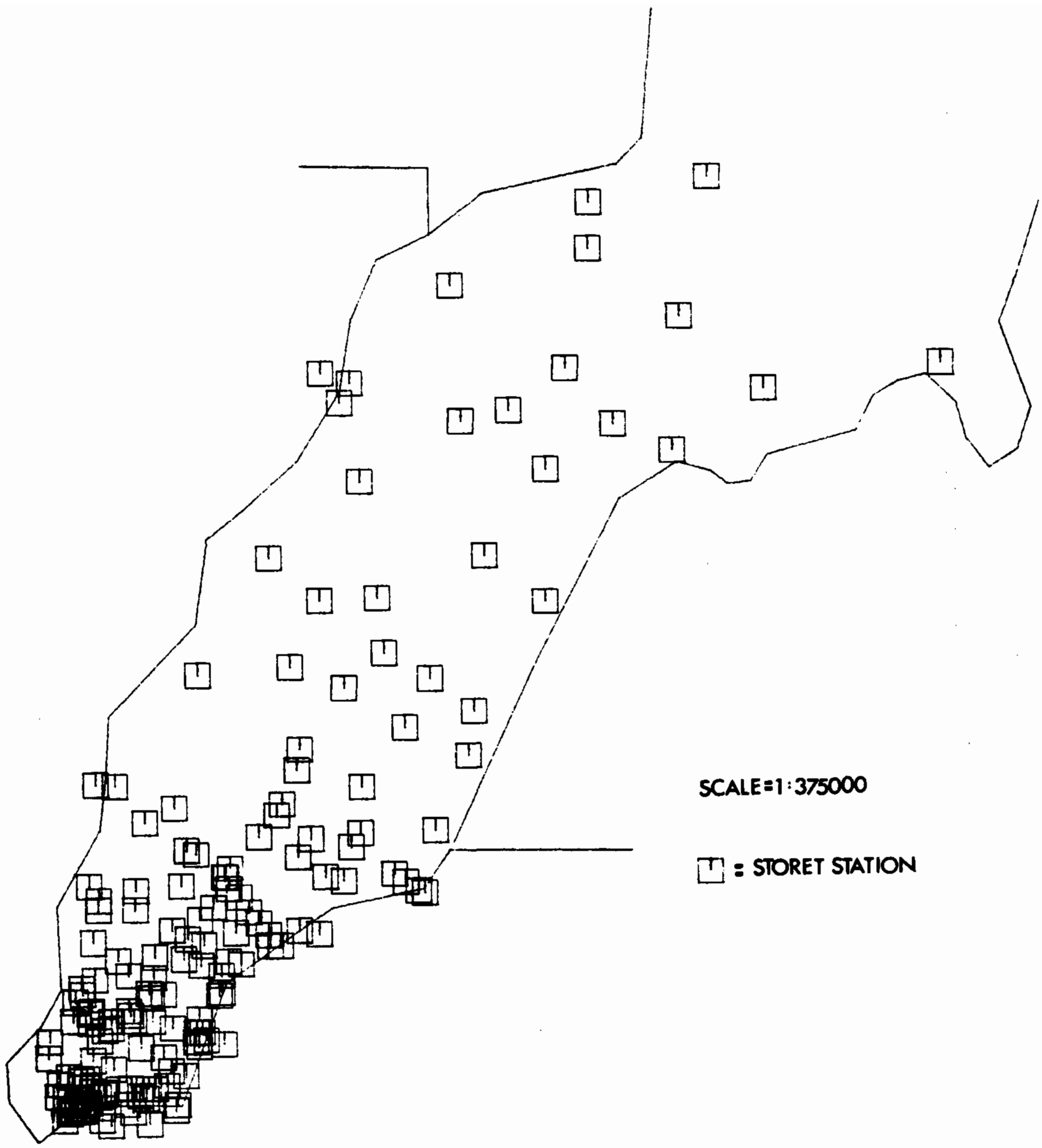

FIGURE 1. STATIONS WITH DATA IN STORET

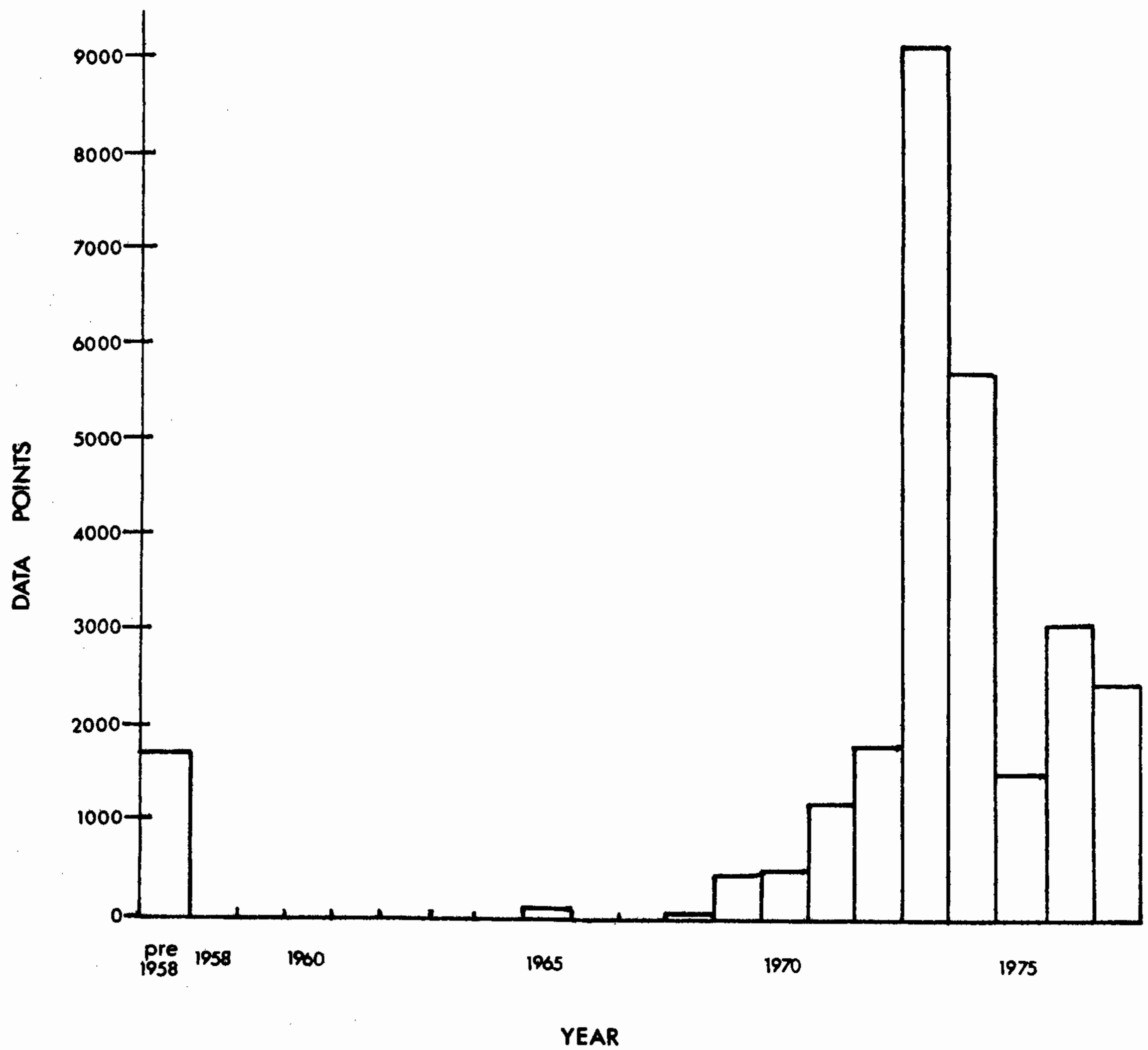

FIGURE 2. DATA POINTS IN STORET

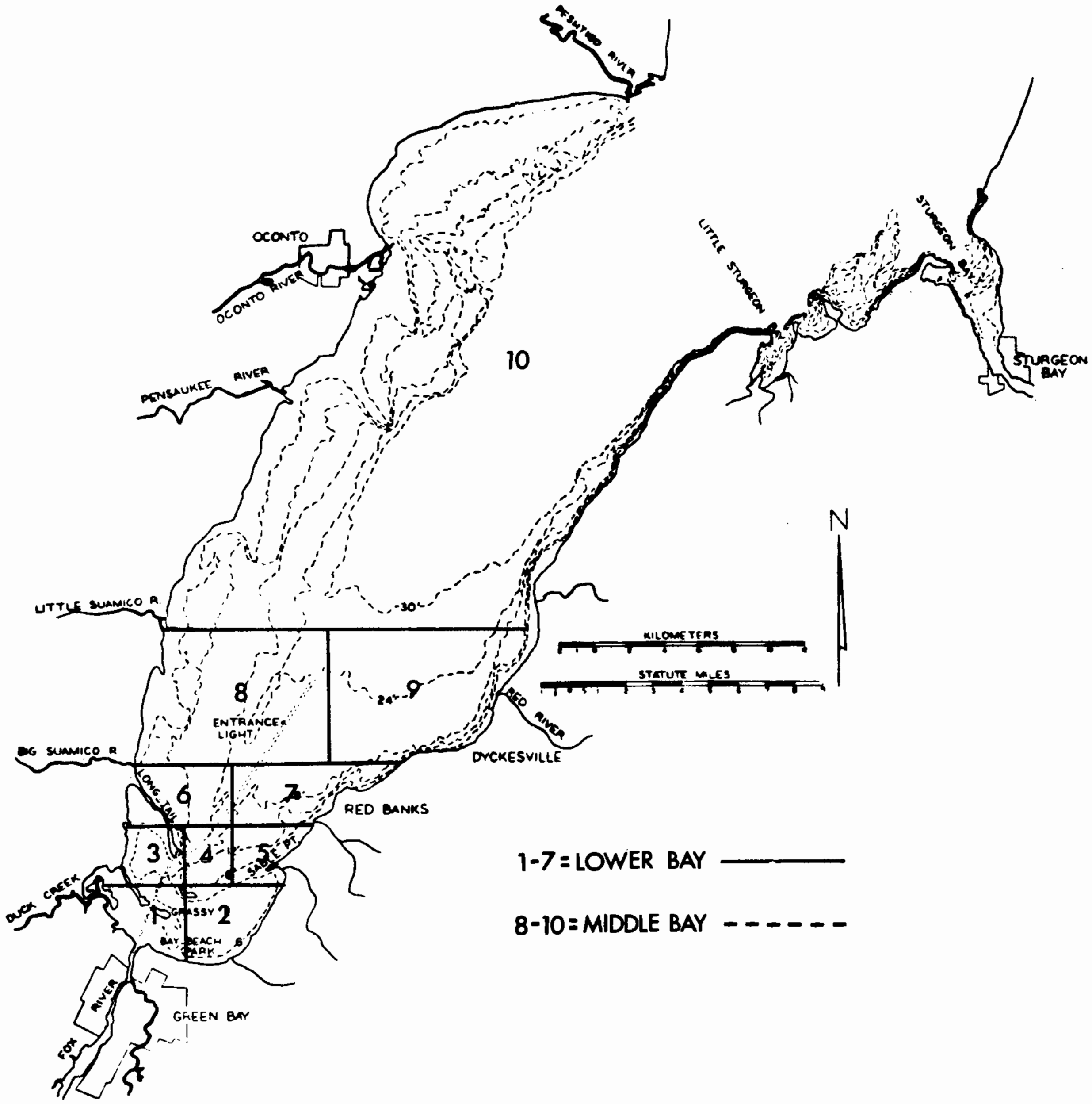

FIGURE 3. REGIONS OF GREEN BAY FOR FIGURES 4-8

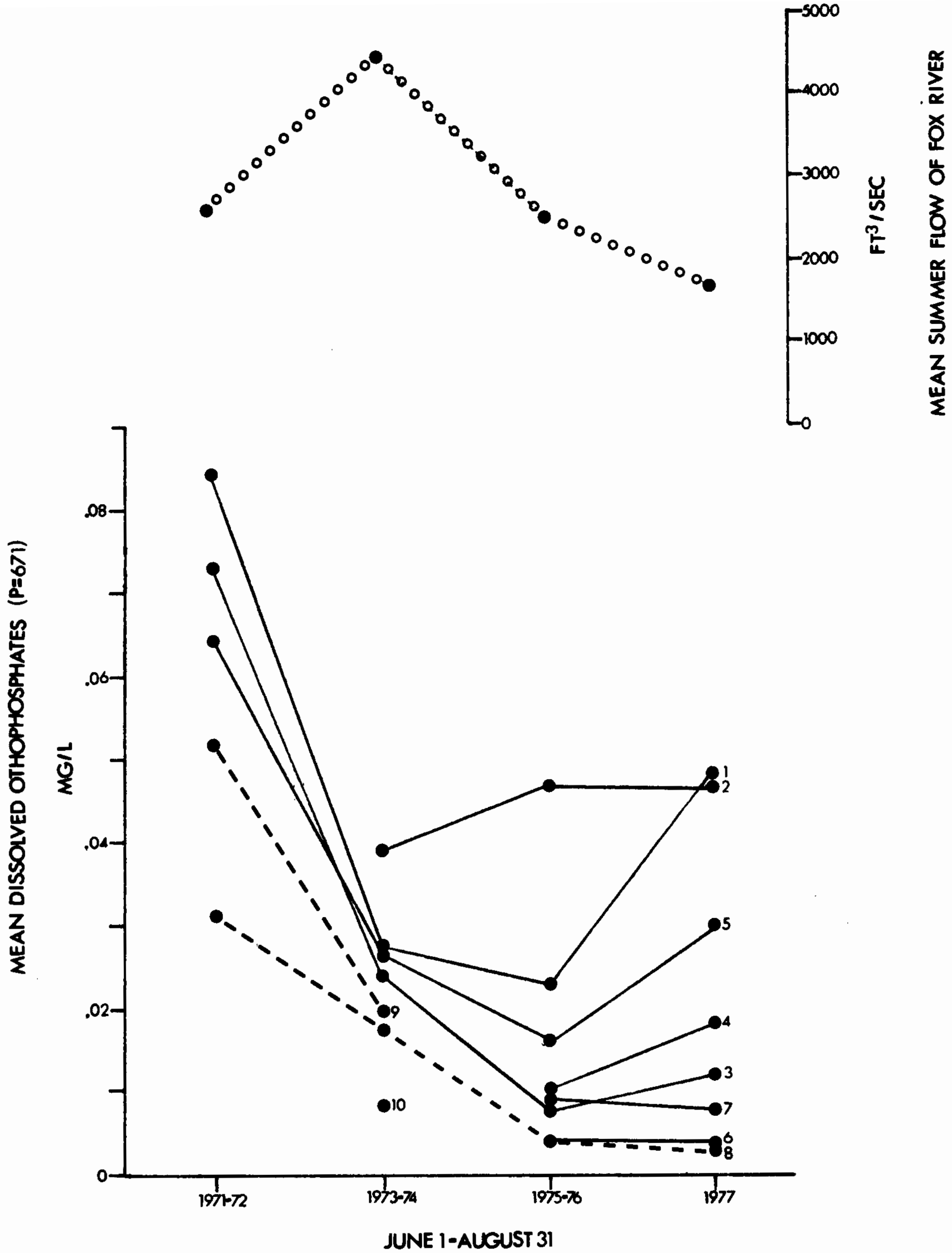

FIGURE 4. DISSOLVED ORTHOPHOSPHATES IN GREEN BAY (SUMMER)

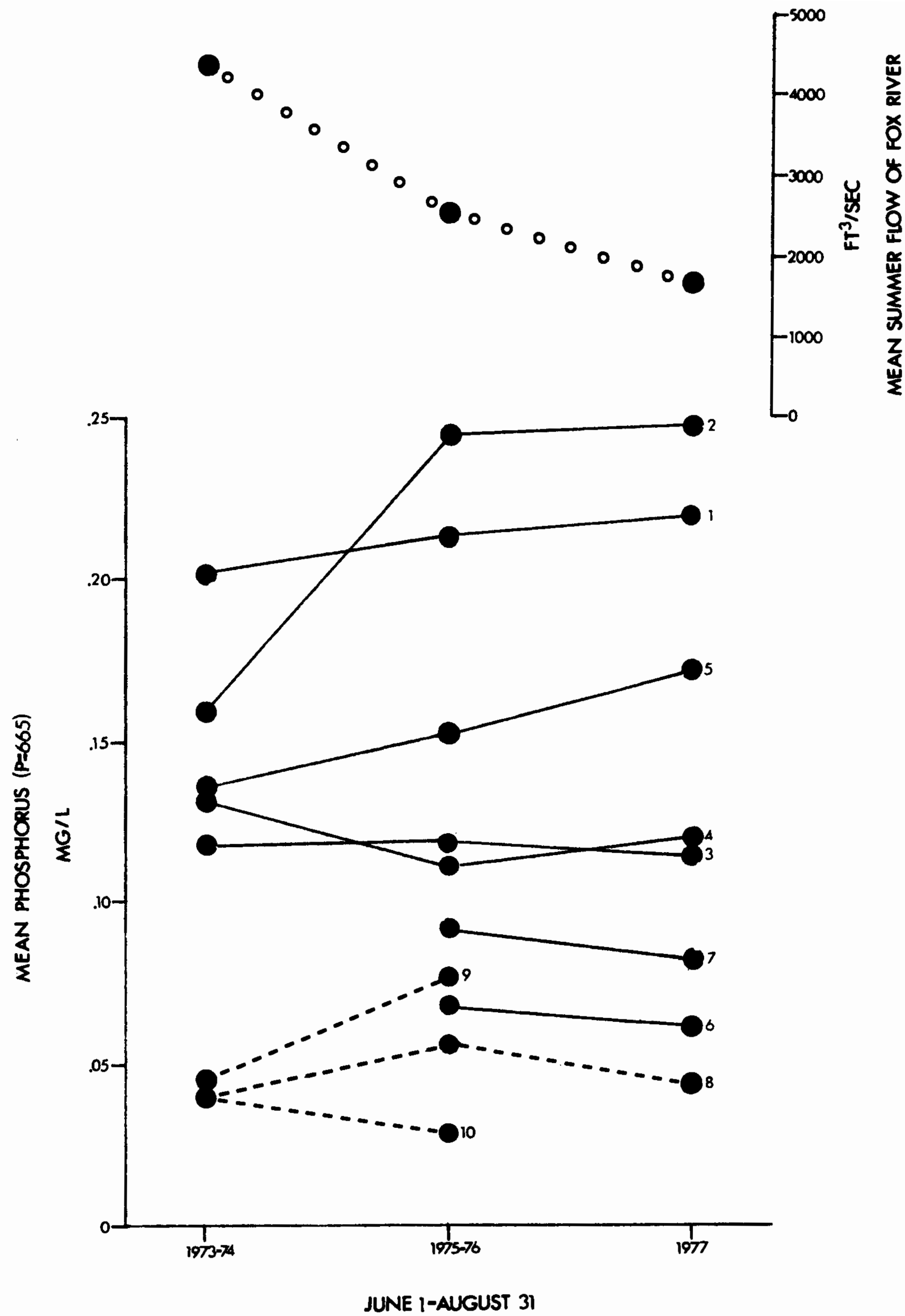

FIGURE 5. TOTAL PHOSPHORUS IN GREEN BAY (SUMMER)

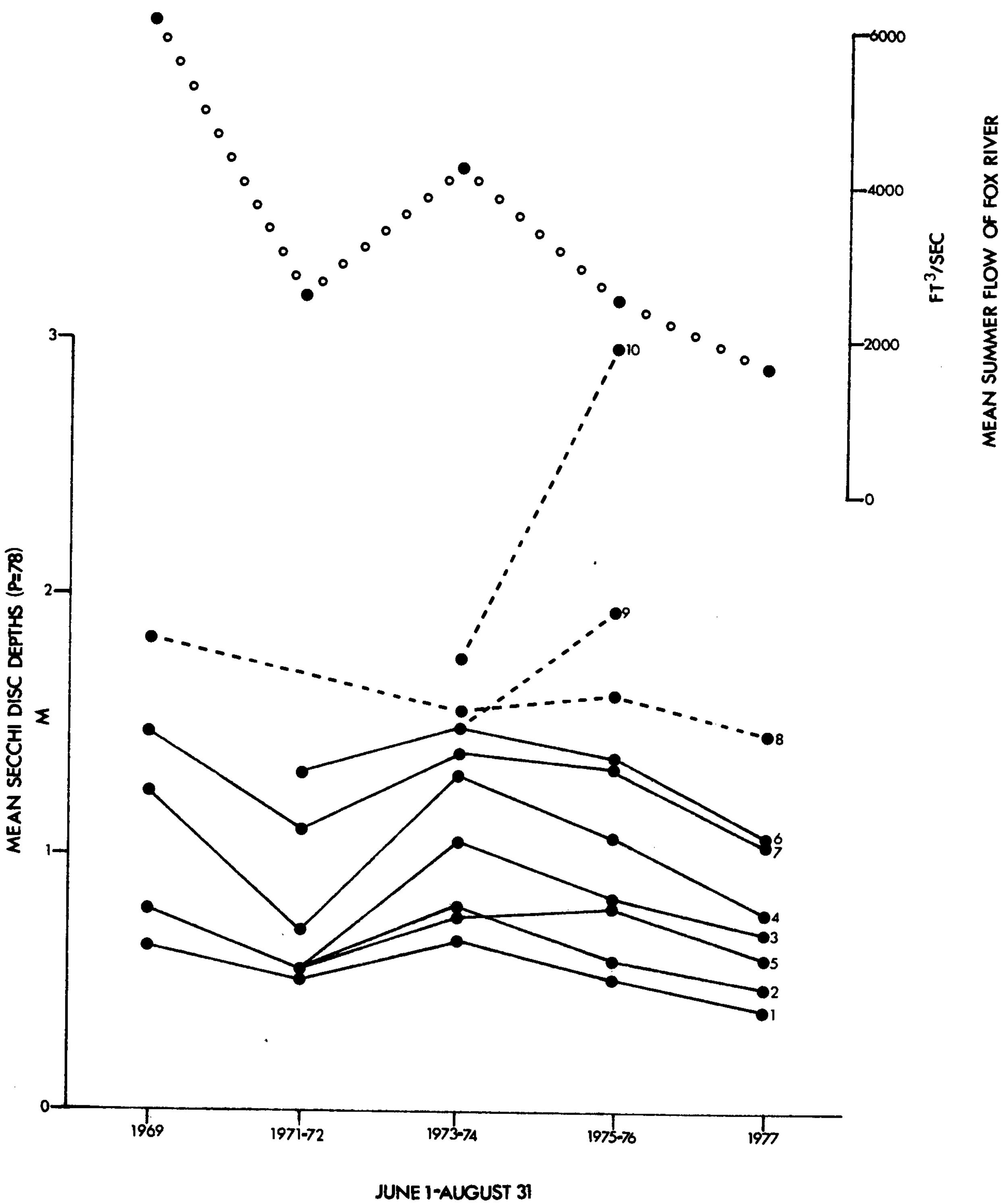

FIGURE 6. TRANSPARENCY OF GREEN BAY (SUMMER)

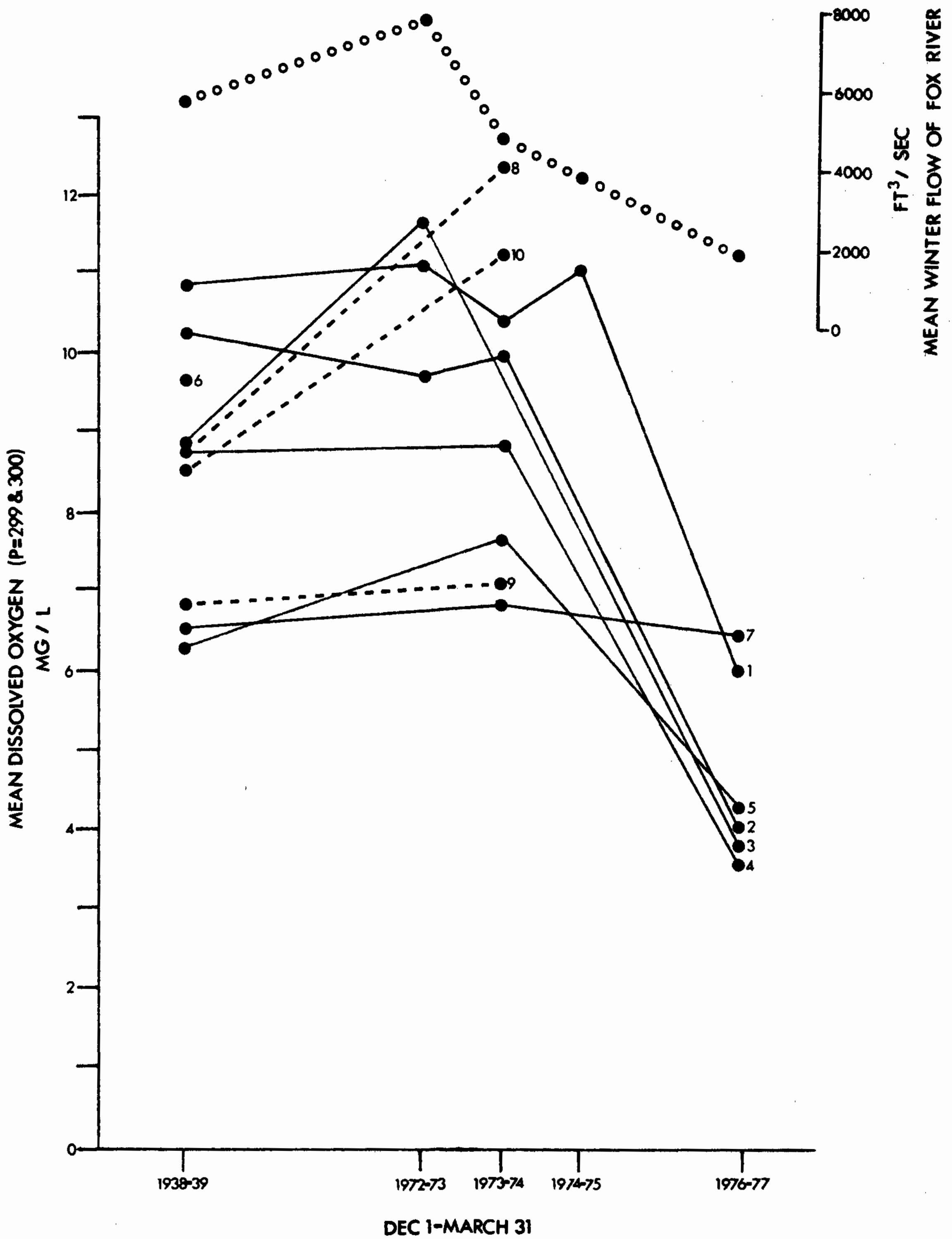

FIGURE 7. DISSOLVED OXYGEN IN GREEN BAY (WINTER)

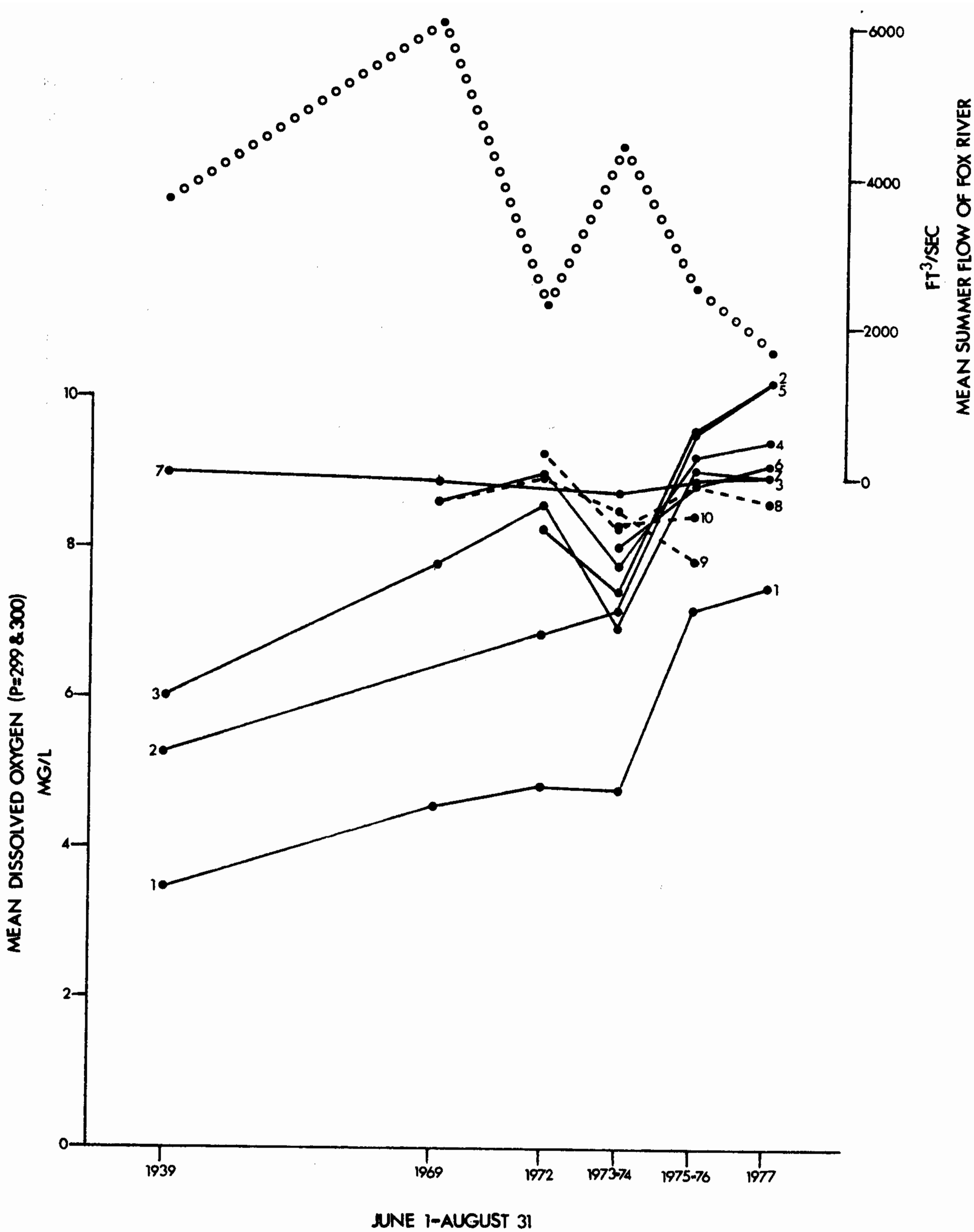

FIGURE 8. DISSOLVED OXYGEN IN GREEN BAY (SUMMER)

TABLE 2A. COMPUTERIZED DATA BASE

Publication from data: Adams and Stone, 1973.

Dates data taken: June 8, 1971 to August 19, 1971.

System used: STORET

STORET Station Code Number	Latitude (deg./min./sec.)	Longitude (deg./min./sec.)
053295	44/41/47	87/59/13.6
053296	44/36/10.4	87/59/17.3
053297	44/34/20.1	87/54/04.9

STORET Parameter Code Number	Parameter Tested
10	Water Temperature (°C)
30	Incident Light ($C/cm^2/D$)
94	Specific Field Conductance (umhos/cm)
400	pH (standard units)
410	Total Alkalinity (mg/l as $CaCO_3$)
610	Ammonia (mg/l as N)
620	Nitrate (mg/l as N)
665	Phosphorus (mg/l)
666	Dissolved Phosphorus (mg/l as P)
671	Dissolved orthophosphate (mg/l as P)

TABLE 2B. COMPUTERIZED DATA BASE

Publication from data: Allen, 1966.

Dates data taken: April 28, 1965 to November 5, 1965.

System used: STORET

STORET Station Code Number	Latitude (deg./min./sec.)	Longitude (deg./min./sec.)
153072	44/48/17.5	87/43/31.9

Parameter Code Number	Parameter Tested
631	Dissolved Nitrite plus Nitrate (mg/l as N)
32210	Chlorophyll A-Trichomatic uncorrected (mg/l)
70505	Phosphate - Colorimetric (mg/l as P)
70506	Soluble Phosphate - Colorimetric (mg/l as P)

TABLE 2C. COMPUTERIZED DATA BASE

Publication from data: Howmiller, 1971.

Dates data taken: October 20, 1966 to May 3, 1971.

System used: BIOSTORET

BIOSTORET Station Code Number	Latitude (deg./min./sec.)	Longitude (deg./min./sec.)
053241	44/32/50	88/00/00
053242	44/33/21	87/59/37
053243	44/33/58	87/59/24
053244	44/34/48	87/58/48
053245	44/35/20	87/57/50
053246	44/35/42	87/57/06
053247	44/36/24	87/56/29
053248	44/37/17	87/56/15
053249	44/38/17	87/54/34
053250	44/39/06	87/54/00
053324	44/23/25	88/00/09
053325	44/32/25	87/58/34
053326	44/32/25	87/57/22
053327	44/32/25	87/56/10
053328	44/33/17	87/59/45
053329	44/33/17	87/58/34
053330	44/33/17	87/57/22
053331	44/33/17	87/56/10
053332	44/33/17	87/54/58
053333	44/34/08	87/56/10
053334	44/34/08	87/54/58
053335	44/34/59	87/59/45
053336	44/34/59	87/58/34
053337	44/34/59	87/57/22
053338	44/35/51	87/59/45
053339	44/35/51	87/58/34
053340	44/35/51	87/57/22
053341	44/35/51	87/56/10
053342	44/36/43	87/58/34
053343	44/36/43	87/57/22
053344	44/36/43	87/56/10
053345	44/36/43	87/53/47
053346	44/36/43	87/52/35
053347	44/37/35	87/59/45
053348	44/37/35	87/58/34
053349	44/37/35	87/57/22
053350	44/37/37	87/56/10
053351	44/37/35	87/54/58
053352	44/37/35	87/53/47
053353	44/37/35	87/52/35
053354	44/38/27	87/59/45
053355	44/38/27	87/54/58
153041	44/45/18	87/47/10

BIOSTORET Station Code Number	Latitude (deg./min./sec.)	Longitude (deg./min./sec.)
153042	44/44/27	87/45/44
153043	44/43/33	87/44/18
153044	44/51/56	87/43/02
153045	44/51/14	87/41/08
153046	44/50/32	87/39/15
153047	44/49/55	87/37/36
153048	44/39/57	87/48/24
433211	44/43/18	87/54/20
433212	44/42/20	87/52/20
433213	44/41/36	87/50/22
433214	44/48/57	87/51/30
433215	44/47/03	87/50/00
433216	44/46/10	87/48/33
433217	44/53/59	87/48/42
433218	44/53/20	87/46/53
433219	44/52/40	87/45/00

TABLE 2D. COMPUTERIZED DATA BASE

Publication from data: Neustadter, 1977.

Dates data taken: January 31, 1977 to March 3, 1977.

System used: STORET

STORET Station Code Number	Latitude (deg./min./sec.)	Longitude (deg./min./sec.)
053005	44/32/55	87/58/56
053007	44/34/48	87/58/37
053008	44/34/14	87/57/26
053010	44/35/00	87/56/58
053012	44/37/53	87/55/02
053013	44/37/30	87/53/35
053014	44/37/08	87/52/12
053016	44/40/16	87/52/39
053017	44/39/41	87/51/05
053018	44/38/59	87/49/14
053019	44/39/06	87/49/58
053020	44/32/10	87/59/00
053021	44/32/03	87/57/05
053022	44/32/27	87/56/02
053023	44/33/04	87/57/08
053024	44/33/26	87/55/37
053025	44/34/16	87/55/05
053027	44/35/44	87/54/16
053028	44/37/34	87/51/02
053031	44/36/43	87/58/21
053032	44/38/10	87/57/39
053254	44/32/37	87/58/00
053335	44/34/59	87/59/45

STORET Parameter Code Number	Parameter tested
10	Water Temperature (^{o}C)
299	Dissolved Oxygen-electrode (mg/l)
1003	Arsenic-bottom deposits (mg/kg)
1008	Barium-bottom deposits (mg/kg)
1028	Cadmium-bottom deposits (mg/kg)
1029	Chromium-bottom deposits (mg/kg)
1068	Nickel-bottom deposits (mg/kg)
1093	Zinc-bottom deposits (mg/kg)
1148	Selenium-bottom deposits (mg/kg)
71921	Mercury-bottom deposits (mg/kg)

TABLE 2E. COMPUTERIZED DATA BASE

Publications from data: Sager & Wiersma 1972, 1975, 1977.

Dates data taken: June 17, 1969 to August 22, 1977.

System used: STORET

STORET Station Code Number	Latitude (deg./min./sec.)	Longitude (deg./min./sec.)
053003	44/32/25	88/00/14
053004	44/33/08	87/59/53
053005	44/32/55	87/58/56
053006	44/33/53	87/59/21
053007	44/34/48	87/58/37
053008	44/34/14	87/57/26
053009	44/35/26	87/59/46
053010	44/35/00	87/56/58
053011	44/36/46	87/55/42
053012	44/37/53	87/55/02
053015	44/39/22	87/53/49
053022	44/32/27	87/56/02
053024	44/33/26	87/55/37
053025	44/34/16	87/55/05
053026	44/35/03	87/55/05
053028	44/37/34	87/51/02
053032	44/38/10	87/57/39
053034	44/37/14	87/59/21
053251	44/33/25	88/00/20
053253	44/32/28	88/00/18
053254	44/32/37	87/58/00
053255	44/35/00	88/00/10
053256	44/33/06	87/50/50
053257	44/34/40	87/55/11
053258	44/35/46	87/56/31
053259	44/36/18	87/57/56
053260	44/38/51	87/59/30
053261	44/37/09	87/54/52
053262	44/36/37	87/53/23
053263	44/40/41	87/57/16
053265	55/35/10	87/57/51.5
053269	44/39/53	87/55/35
053270	44/38/32	87/53/27
053271	44/32/26	87/59/42
053272	44/32/31	87/59/00
053273	44/32/36	87/59/39
053274	44/32/40	87/59/48
053275	44/32/46	88/00/00
053276	44/32/47	87/57/13
053277	44/32/47	88/00/28
053278	44/32/50	87/59/09
053279	44/33/00	87/59/23
053280	44/33/12	88/00/42
053281	44/33/38	87/58/32

STORET Station Code Number	Latitude (deg./min./sec.)	Longitude (deg./min./sec.)
053283	44/33/58	87/56/32
053284	44/34/26	87/59/05
053285	44/35/14	87/59/30
053324	44/32/25	88/00/09
053350	44/37/35	87/56/10
433220	44/40/41	87/52/20

STORET Parameter Code Number	Parameter tested
10	Water Temperature (^{o}C)
76	Turbidity-Hach (Formazin Turb Unit)
78	Transparency-Secchi disk (m)
94	Specific Field Conductance (umhos/cm)
300	Dissolved Oxygen (mg/l)
301	Dissolved Oxygen (% saturation)
340	Chemical Oxygen Demand (mg/l)
341	Chemical Oxygen Demand-dissolved (mg/l)
403	pH-lab (standard units)
410	Alkalinity (mg/l as $CaCO_3$)
608	Ammonia (mg/l as N)
631	Nitrite plus Nitrate (mg/l as N)
660	Orthophosphate (mg/ as PO_4)
665	Phosphorus (mg/l as P)
671	Dissolved Orthophosphate (mg/l as P)
32211	Chlorophyll A-Spectrophotometric (mg/l)
32218	Pheophytin A-Spectrophotometric (mg/l)
71886	Phosphorus (mg/l as PO_4)
71889	Soluble Orthophosphate (mg/l as PO_4)

TABLE 2F. COMPUTERIZED DATA BASE

Publication from data: Sridharan, 1972.

Dates data taken: October 28, 1968 to October 6, 1969.

System used: STORET

STORET Station Code Numbers	Latitude (deg./min./sec.)	Longitude (deg./min./sec.)
053298	44/34/48	88/00/21.1
053299	44/34/48	88/00/43.7
053300	44/34/25	88/01/06.3
053301	44/32/25	87/59/49
053302	44/33/10	87/56/23.8
053303	44/32/23.8	87/57/46.2
053304	44/35/33	88/00/04
053305	44/35/56	87/59/49
053306	44/36/14	87/56/55.5
053307	44/36/50	87/56/52
053308	44/38/10	87/59/08.2
053309	44/38/14	87/54/30
053310	44/40/12	87/50/33
433226	44/45/07.3	87/51/23.5
433227	44/50/26.5	87/48/32.5
433228	44/52/27.4	87/42/30

STORET Parameter Code Number	Parameter tested
10	Water Temperature (^{o}C)
94	Specific Field Conductance (umhos/cm)
299	Dissolved Oxygen-electrode (mg/1)
400	pH (standard units)
410	Total Alkalinity (mg/1 as $CaCO_3$)
665	Phosphorus (mg/1 as P)
667	Phosphorus-suspended (mg/1)
668	Phosphorus-bottom deposits (mg/kg)
671	Dissolved Orthophosphate (mg/1 as P)
673	Dissolved Phosphorus (mg/1 as P)
687	Organic Carbon-bed (gm/kg)
693	Organic and Inorganic Carbon-bottom deposits (gm/kg)
916	Calcium (mg/1)
917	Calcium-bottom deposits (mg/kg)
924	Magnesium-bottom deposits (mg/kg)
927	Magnesium (mg/1)
929	Sodium (mg/1)
940	Chloride (mg/1 as Cl)
1053	Manganese-bottom deposits (mg/kg)
1108	Aluminum-bottom deposits (mg/kg)
1170	Iron-bottom deposits (mg/kg)
70318	Solids (% of wet sample)

TABLE 2G. COMPUTERIZED DATA BASE

Publication from data: Surber and Cooley, 1952.

Dates data taken: May 26, 1952 to November 5, 1952.

System used: BIOSTORET

BIOSTORET Station Code Number	Latitude (deg./min./sec.)	Longitude (deg./min./sec.)
053241	44/32/50	88/00/00
053242	44/33/21	87/59/37
053243	44/33/58	87/59/24
053244	44/34/48	87/58/48
053245	44/35/20	87/57/50
053246	44/35/42	87/57/06
053247	44/36/24	87/56/29
053248	44/37/17	87/56/15
053249	44/38/17	87/54/34
053250	44/39/06	87/54/00
153041	44/45/18	87/47/10
153042	44/44/27	87/45/44
153043	44/43/33	87/44/18
153044	44/51/56	87/43/02
153045	44/51/14	87/41/08
153046	44/50/32	87/39/15
153047	44/49/55	87/37/36
153048	44/39/57	87/48/24
433211	44/43/18	87/54/20
433212	44/42/20	87/52/20
433213	44/41/36	87/50/22
433214	44/48/57	87/51/30
433215	44/47/03	87/50/00
433216	44/46/10	87/48/33
433217	44/53/59	87/48/42
433218	44/53/20	87/46/53
433219	44/52/40	87/45/00

TABLE 2H. COMPUTERIZED DATA BASE

Publications from data: Vanderhoef et al, 1972, 1974.

Dates data taken: June 9, 1971 to August 25, 1973.

System used: BIOSTORET and STORET

BIOSTORET and STORET Station Code Number	Latitude (deg./min./sec.)	Longitude (deg./min./sec.)
053242	44/33/21	87/59/37
053250	44/39/06	87/54/00
053336	44/35/00	87/58/38
053362	44/32/21	88/00/18
053400	44/35/39.7	87/57/00
153071	44/41/12	87/51/44
153111	44/52/02.7	87/38/17.8
433242	44/59.07.3	87/34/26.2

STORET Parameter Code Number	Parameter tested
10	Water Temperature (°C)
20	Air Temperature (°C)
35	Wind Velocity (M.P.H.)
36	Wind Direction (° true North)
94	Specific Field Conductance (umhos/cm)
299	Dissolved Oxygen-electrode (mg/l)
600	Nitrogen (mg/l)
610	Ammonia (mg/l as N)
615	Nitrite (mg/l as N)
620	Nitrate (mg/l as N)
671	Dissolved Orthophosphate (mg/l as P)

TABLE 21. COMPUTERIZED DATA BASE

Publication from data: Veith, 1975.

Dates data taken: July 21, 1971 to November 1, 1971.

System used: BIOSTORET

BIOSTORET Station Code Number	Latitude (deg./min./sec.)	Longitude (deg./min./sec.)
153073	45/04/00	87/31/00
433225	44/50/00	87/46/00

TABLE 2J. COMPUTERIZED DATA BASE

Publication from data: W.P.S, 1974.

Dates data taken: January 25, 1973 to November 11, 1973.

System used: BIOSTORET and STORET

BIOSTORET and STORET Station Code Number	Latitude (deg./min./sec.)	Longitude (deg./min./sec.)
053003	44/32/25	88/00/14
053004	44/33/08	87/59/53
053005	44/32/55	87/58/56
053006	44/33/53	87/59/21
053008	44/34/14	87/57/26
053009	44/35/26	87/59/46
053010	44/35/00	87/56/58
053022	44/32/27	87/56/02
053025	44/34/16	87/55/05
053051	44/33/25	88/00/20
053254	44/32/37	87/58/00
053256	44/33/06	87/50/50
053271	44/32/26	87/59/42
053272	44/32/31	87/59/00
053273	44/32/36	87/59/39
053274	44/32/40	87/59/48
053275	44/32/46	87/00/00
053276	44/32/47	87/57/13
053277	44/32/47	88/00/28
053278	44/32/50	87/59/09
053279	44/33/00	87/59/23
053280	44/33/12	88/00/42
053281	44/33/38	87/58/32
053282	44/33/57	88/01/10
053283	44/33/58	87/56/32
053284	44/34/26	87/59/05
053285	44/35/14	87/59/20

STORET Parameter Code Number	Parameter tested
10	Water Temperature (°C)
76	Turbidity-Hach (Formazin Turb. Units)
80	Color (platinum-cobalt units)
94	Specific Field Conductance (umhos/cm)
300	Dissolved Oxygen (mg/l)
403	pH (standard units)
410	Alkalinity (mg/l as $CaCO_3$)
530	Residue-nonfiltrable (mg/l)
608	Ammonia (mg/l as N)
613	Dissolved Nitrite (mg/l as N)
618	Dissolved Nitrate (mg/l as N)
625	Nitrogen-Kjeldahl (mg/l)

STORET Parameter Code Number	Parameter tested
665	Phosphorus (mg/l)
671	Dissolved Orthophosphate (mg/l as P)
680	Organic Carbon (mg/l)
685	Inorganic Carbon (mg/l)
690	Carbon (mg/l)
915	Calcium (mg/l)
925	Dissolved Magnesium (mg/l)
930	Dissolved Sodium (mg/l)
935	Dissolved Potassium (mg/l)
940	Chloride (mg/l)
946	Dissolved Sulfate (mg/l)
955	Dissolved Silica (mg/l)
956	Silica (mg/l)
74010	Iron (mg/l)

TABLE 2K. COMPUTERIZED DATA BASE

Publication from data: W.P.S, 1976.

Dates data taken: September 17, 1974 to August 18, 1975.

System used: BIOSTORET and STORET

BIOSTORET and STORET Station Code Number	Latitude (deg./min./sec.)	Longitude (deg./min./sec.)
053311	44/32/14	88/00/25
053312	44/32/13	88/00/28
053313	44/32/30	88/00/28
053314	44/32/28	88/00/26
053316	44/32/50	88/00/47
053318	44/33/19	88/00/51
053319	44/32/30	87/59/49
053320	44/32/23	87/59/52
053321	44/33/04	87/58/20
053323	44/32/09	87/58/56

STORET Parameter Code Number	Parameter tested
10	Water Temperature (^{o}C)
76	Turbidity-Hach (Formazin Turb. Units)
94	Specific Field Conductance (umhos/cm)
300	Dissolved Oxygen (mg/l)
301	Dissolved Oxygen (% saturation)
310	Biochemical Oxygen Demand (mg/l/5 day)
370	Chlorine Demand (mg/l/hour)
400	pH (standard units)
410	alkalinity (mg/l as $CaCO_3$)
530	Residue-nonfiltrable (mg/l)
550	Oil and Grease-Soxhlet (mg/l)
605	Organic Nitrogen (mg/l)
610	Ammonia (mg/l as N)
620	Nitrate (mg/l as N)
665	Phosphorus (mg/l)
671	Dissolved Orthophosphate (mg/l as P)
680	Organic Carbon (mg/l)
740	Sulfite (mg/l)
745	Sulfide (mg/l)
916	Calcium (mg/l)
927	Magnesium (mg/l)
929	Sodium (mg/l)
940	Chloride (mg/l)
945	Sulfate (mg/l)

STORET Parameter Code Number	Parameter tested
950	Dissolved Fluoride (mg/l)
955	Dissolved Silica (mg/l)
1002	Arsenic (ug/l)
1012	Berylium (ug/l)
1022	Boron (ug/l)
1027	Cadmium (ug/l)
1032	Chromium-hexavalent (ug/l)
1034	Chromium (ug/l)
1042	Copper (ug/l)
1045	Iron (ug/l)
1051	Lead (ug/l)
1055	Manganese (ug/l)
1067	Nickel (ug/l)
1092	Zinc (ug/l)
1147	Selenium (ug/l)
31613	Fecal Coliform-agar (num./100 ml)
31673	Fecal Streptococci-agar (num./100 ml)
32730	Phenolics-recoverable (ug/l)
50060	Chlorine-residual (mg/l)
50064	Chlorine-free available (mg/l)
70300	Residue-filtrable (mg/l)
71900	Mercury (ug/l)

TABLE 2L. COMPUTERIZED DATA BASE

Publication from data: Wisconsin State Committee on Water Pollution, 1939.

Dates data taken: October 4, 1938 to October 5, 1939.

System used: STORET

STORET Station Code Number	Latitude (deg./min./sec.)	Longitude (deg./min./sec.)
053251	44/33/25	88/00/20
053259	44/36/18	87/57/56
053360	44/39/07	87/54/03
053362	44/32/21	88/00/18
053367	44/32/36	87/55/58
053386	44/33/34.2	87/56/13.3
053387	44/36/35.2	87/55/00
053388	44.35/48.3	87/54/09.6
053389	44/35/28	87/54/36.2
053390	44/36/18	87/54/11
053391	44/36/42	87/53/54.1
053392	44/35/17	87/59/24
053393	44/38/43.7	87/57/37.9
053394	44/38/12.9	87/56/40.5
053395	44/37/58.5	88/00/08.6
053396	44/34/03.2	87/58/25
053397	44/33/53.6	87/59/00
053398	44/34/56	87/59/27
053399	44/34/30.1	87/58/00.1
053400	44/35/39.7	87/57/00.4
053406	44/30/07.5	88/00/30.3
053408	44/32/06	87/58/36
053409	44/32/58.4	87/58/52.9
053410	44/33/06.5	87/59/37.1
053411	44/32/52.3	87/57/28.6
053412	44/33/18	87/59/50
053413	44/38/51.1	87/55/48.1
053414	44/36/36.6	87/58/21.8
053415	48/38/42	87/46/14.4
053416	44/38/38	87/45/59
053417	44/38/57	87/46/44
053418	44/40/22	87/48/33
053419	44/39/45.5	87/55/11.6
053420	44/35/00	87/57/43.3
053421	44/35/17.7	87/57/55.5
053422	44/34/41.3	87/54/58
053423	44/34/27.6	87/54/47.8
053424	44/34/24.2	87/55/13.3
053425	44/34/21.8	87/55/03.1
053426	44/37/08.4	87/51/47.8
053427	44/37/27.8	87/50/14.1
053428	44/38/36.2	87/49/233.8
053429	44/37/26.4	87/52/16.6
053430	44/37/47.3	87/52/40.4
053431	44/38/06.2	87/53/30.9

STORET Station Code Number	Latitude (deg./min./sec.)	Longitude (deg./min./sec.)
053432	44/38/27.4	87/53/30.9
053433	44/38/46.7	87/53/51.7
053434	44/37/20.1	87/55/32
053435	44/34/44.1	87/58/54.1
053436	44/34/30.2	87/58/57.2
053437	44/33/04	87/56/52.1
053438	44/35/47	87/57/06.6
053439	44/35/43	87/55/44.7
053440	44/35/01	87/56/18.2
053441	44/34/20.5	87/57/09.7
053442	44/39/44.1	87/49/30.4
053443	44/39/11.6	87/50/26.9
053444	44/40/00	87/51/48.7
053445	55/50/22	87/45/00
053446	44/32/48.8	87/59/49.5
053447	44/32/00	87/58/38
053448	44/32/40	87/59/34.3
153098	44/46/57.6	87/41/04.3
153099	44/41/34	87/50/16
153100	44/43/15.1	87/49/33.6
153101	44/41/50.9	87/47/09.1
153102	44/44/30.5	87/47/50.3
153103	44/43/03.4	87/45/50.7
153104	41/41/37.3	87/43/42.8
153105	44/45/58.8	87/46/07.1
153106	44/44/50.9	87/44/48.6
153107	44/43/57.2	87/43/20
153108	44/45/24.3	87/52/11.8
153109	44/46/19.1	87/43/28.6
153110	44/47/13.8	87/44/45.7
433226	44/45/07.3	87/51/23.5
433233	44/42/11	87/51/07.4
433234	44/43/57.8	87/53/40.5
433235	44/41/44.7	87/56/58.9
433236	44/40/45	87/53/14
433237	44/42/41.3	87/55/32.8
433238	44/45/10.1	87/52/19.6
433239	44/45/45.6	87/49/34.3
433240	44/47/04.7	87/47/51.4
433241	44/48/22.7	87/46/15.7

STORET Parameter Code Number	Parameter tested
10	Water Temperature (°C)
80	Color (platinum-cobalt units)
300	Dissolved Oxygen (mg/l)
301	Dissolved Oxygen (% saturation)
310	Biochemical Oxygen Demand (mg/l/5 day)
400	pH (standard units)
410	Alkalinity (mg/l as $CaCO_3$)
500	Residue (mg/l)
505	Residue-volatile (mg/l)
613	Dissolved Nitrite (mg/l as N)
618	Dissolved Nitrate (mg/l as N)
625	Nitrogen-Kjeldahl (mg/l)

SECTION 5

PROPOSED SAMPLING NETWORK

The sampling effort used in a Green Bay monitoring program should be constructed to give an adequate, efficient coverage of the water quality of the area. Representation of the different physical, chemical and biological regions of Green Bay must be achieved. Physical regions are shown (Figure 9) and described (Table 3). The biological and chemical regions of Green Bay (defined by previous biological and chemical sampling) can be identified from the data base (Table 2, A-L).

TABLE 3. PHYSICAL AREAS OF GREEN BAY

Figure 9 Number	Description
1)	Fox River mouth
2)	Fox River mouth to near Bay Beach Park
3)	Navigational channel to east shore and Long Tail Point - Point Sable bar
4)	Dead Horse Bay and Duck Creek area
5)	Point Sable to navigational channel
6)	East shore near Red Banks
7)	East shore near Dyckesville
8)	Near 10 mile entrance light
9)	West shore, Long Tail Point to Little Suamico mouth
10)	West shore near Pensaukee River mouth
11)	10 mile entrance light to Little Sturgeon Bay
12)	East shore southwest of Little Sturgeon Bay
13)	East shore near Little Sturgeon Bay
14)	West shore near Oconto River mouth
15)	West shore near Peshtigo River mouth
16)	West shore of Sturgeon Bay
17)	Little Sturgeon Bay to Green Island

The network design must be simple to allow dependability of sampling under various weather conditions and increase time and cost efficiency. The safety of personnel and equipment should not be compromised, by sampling stations located near navigational hazards such as reefs and shoals or by water too shallow to be accessable in low water years. Accuracy can be within 100 feet in or near navigational channels, in inner Green Bay or nearshore areas within 500 feet, and in outer Green Bay within 2500 feet.

Much of the historical data is taken along the navigational areas for accuracy of station location, and safe access when deeper draft boats are used. While nearly all of the proposed network would be out of navigational areas, some stations should be sampled in the channel to allow a connection with the historical record.

Winter sampling has a different set of criteria. The tracing of the low dissolved oxygen plume along the eastern shore of Green Bay is the main objective. A transect of stations parallel to the shore would be an important part of the network. Stations would be located in safe ice areas with commercial fishermen a possible source of ice information.

With the above factors taken into consideration, stations for the proposed network were selected (Figure 10, Table 4) that had the best possible data base. For purposes of water chemistry sampling, they were almost all Wisconsin Department of Natural Resources stations. These stations were frequently used (albeit unknowingly) by Doctors Sager and Wiersma (1972, 1975, 1977). Very little biological data has been collected at these stations. There are several stations, especially in inner Green Bay, which have biological data and nearly overlap with the selected chemical stations. They are listed (Table 4) and could be used in future comparisons: either sampling biological stations and assuming the chemistry is the same as the nearby chemistry station or by sampling the chemical station and using the computerized biological station for historical reference.

Far more controversial than the question of where to sample is the question of how often. Every experienced sampler interviewed gave a different answer. Nearly all of the parameters received a wide range of suggested sampling frequencies.

Modelers wanted nutrients sampled six times yearly, but suggested biological samples could be taken every five years. Biologists wanted all biological samples taken a minimum of four times a year. Because of this diversity of opinion, it is obvious why the sampling of Green Bay appears to have been done in a haphazard manner. It is important to note that the modelers' and biologists' answers are not totally conflicting, but merely show a different orientation.

Parameters chosen (Table 5, A-H) are those that are 1) dependable, 2) contain large quantities of implicit data (such as dissolved oxygen), and 3) reflect some critical aspects of Green Bay water quality. If all of the parameters were sampled every year on the monthly basis suggested by some scientists, the costs in manpower, time and money would be prohibitive. While many of the parameters should be sampled several times a year, relatively few of them need to be sampled every year.

Only minimal sampling of toxics is suggested here, but there will be an ever increasing need to sample for this aspect of the water quality program. A more comprehensive toxic sampling scheme may be required and devised in the future and should include present sampling stations.

At least once during the summer, an effort should be made to do both vertical (depth) and diurnal profiles. This should be done in the years nutrient sampling is done.

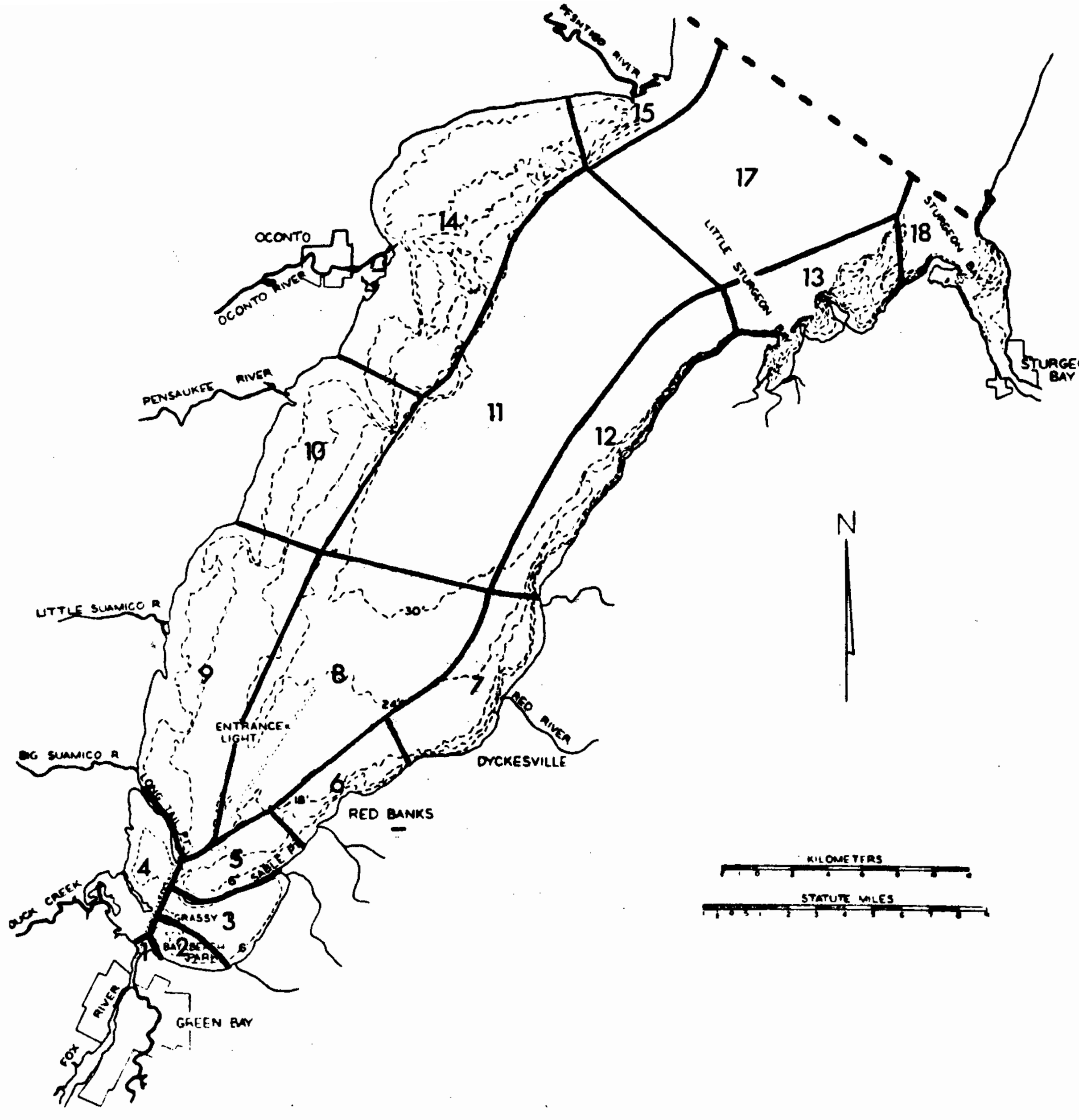

FIGURE 9. PHYSICAL AREAS OF GREEN BAY

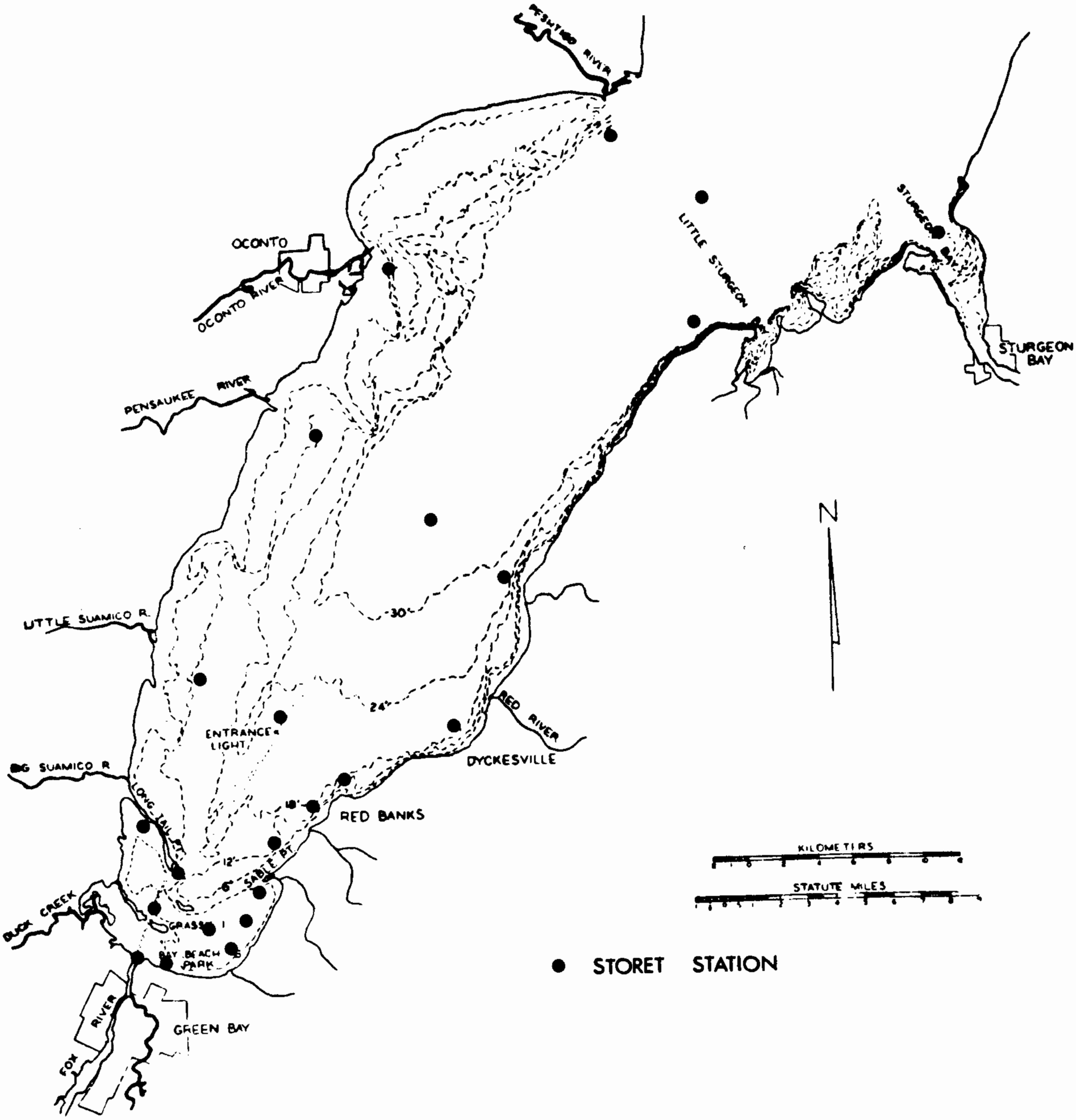

FIGURE 10. PROPOSED SAMPLING NETWORK

TABLE 4. RECOMMENDED STATIONS FOR GREEN BAY MONITORING

Chemical Sampling Station	Nearby Biological station	DNR station number	Latitude deg./min./sec.	Latitude deg./min./sec.
053003	053241	2	44/32/25	88/00/14
053020		10	44/32/10	87/59/00
053006	053242	4	44/23/53	87/59/21
053007	053244	5	44/34/48	87/58/37
053009		6	44/35/46	87/59/46
053022		12	44/32/27	87/56/02
053023		13	44/33/04	87/57/08
053024		13a	44/33/26	87/55/37
053027		15	44/35/44	87/54/16
053014		8c	44/37/08	87/52/12
053028		16	44/37/34	87/51/02
053025		14	44/34/16	87/55/05
053015	053250	9	44/39/22	87/53/49
053263		23	44/40/41	87/57/16
053029	153043	16a	44/39/11	87/57/16
153008		32	44/43/51	87/43/58
153015	153047	40	44/51/18	87/35/55
153018		45	44/53/44	87/25/06
153016		43	44/55/08	87/35/37
383004		42	44/57/05	87/39/16
433011	433214	29	44/48/15	87/52/14
433014	433217, 433218	34	44/53/15	87/48/56
153006	433212, 433213	31	44/45/30	87/47/35

TABLE 5A. PROPOSED OPEN WATER SAMPLING

Storet Parameter Code Number	Parameter Description
10	Water Temperature (°C)
78	Transparency, secchi disk (m)
94	Specific conductance (umhos/cm 225°C)
300	Dissolved oxygen (mg/l)
301	Dissolved oxygen (% of saturation)
310	Biochemical oxygen demand (mg/l, 5 day - 20°C)
400	pH (standard units)
940	Chloride (mg/l as Cl) -- Sampled at Fox River mouth only

Frequency: Monthly, ice out until November.

Scheduling: All years.

Stations to be sampled (STORET code number): 053003, 053006, 053007, 053009, 053015, 053020, 053022, 053025, 053028, 053029, 053263, 153006, 153008, 153015, 153016, 153018, 383004, 433011, 433014.

Comments: Open water parameters can be sampled from a small boat with equipment onboard.

TABLE 5B. PROPOSED WINTER SAMPLING

STORET Parameter Code Number	Parameter Description
10	Water Temperature (^{o}C)
300	Dissolved oxygen (mg/1)
301	Dissolved oxygen (% of saturation)

Frequency: At least twice during the winter.

Scheduling: All years.

Stations to be sampled (STORET code number): 053003, 053006, 053007, 053014, 053015, 053020, 053022, 053023, 053024, 053025, 053027, 053029, 053263, 153008, 153015, 153016, 153018, 383004, 433011, 433014.

Comments: Taken in the nearshore area on the east side of Green Bay to measure the plume of low dissolved oxygen.

TABLE 5C. PROPOSED YEAR ROUND SAMPLING

STORET Parameter Code Number	Parameter Description
530	Residue, total nonfiltrable (mg/l)
610	Nitrogen, ammonia, total (mg/l as N)
625	Nitrogen, Kjeldahl, total (mg/l as N)
630	Nitrite plus nitrate, total (mg/l as N)
665	Phosphorus, total (mg/l as P)
671	Phosphorus, dissolved orthophosphate (mg/l as P)
900	Hardness, total (mg/l as $CaCO_3$)
956	Silica, total (mg/l as SIO_2)
32210	Chlorophyll-A, trichromatic uncorrected (ug/l)

Frequency: Monthly during ice-free period along with open water parameters, twice during ice cover period.

Scheduling: Alternate years.

Stations to be sampled (STORET code number): 053003, 053006, 053007, 053009, 053015, 053020, 053022, 053025, 053028, 053029, 153006, 153008, 153015, 153016, 153018, 383004, 433011, 433014

TABLE 5D. PROPOSED METALS AND TOXICS SAMPLING

STORET Parameter Code Number	Parameter Description
1002	Arsenic, Total (ug/l as As)
1027	Cadmium, total (ug/l as Cd)
1034	Chromium, total (ug/l as Cr)
1042	Copper, total (ug/l as Cu)
1051	Lead, total (ug/l as Pb)
1067	Nickel, total (ug/l as Ni)
1092	Zinc, total (ug/l as Zn)
1147	Selenium, total (ug/l as Se)
39516	PCB in whole water sample (ug/l)
71900	Mercury, total (ug/l as Hg)

Frequency: Once per year.

Scheduling: Alternate years.

Stations to be sampled (STORET code number): 053003, 053007, 053015, 053025, 053028, 053263, 153006, 153016.

Comments: Due to high cost of analysis and slow rate of change, metals may not need to be sampled every year, but future developments may alter this schedule.

TABLE 5E. PROPOSED SEDIMENT SAMPLING

STORET Parameter Code Number	Parameter Description
611	Nitrogen, ammonia, bottom deposits (mg/kg-N)
627	Nitrogen, Kjeldahl, total, bottom deposits (dry wt-mg/kg-N)
633	Nitrite plus nitrate, bottom deposits (dry wt-mg/kg-N)
668	Phosphorus, bottom deposits (dry wt-mg/kg-P)
1003	Arsenic, bottom deposits (dry wt-mg/kg-As)
1028	Cadmium, bottom deposits (dry wt-mg/kg-Cd)
1029	Chromium, bottom deposits (dry wt-mg/kg-Cr)
1043	Copper, bottom deposits (dry wt-mg/kg-Cu)
1052	Lead, bottom deposits (dry wt-mg/kg-Pb)
1068	Nickel, bottom deposits (dry wt-mg/kg-Ni)
1093	Zinc, bottom deposits (dry wt-mg/kg-Zn)
1148	Selenium, bottom deposits (dry wt-mg/kg-Se)
39519	PCB, bottom deposits (dry solids-mg/kg)
70511	Phosphorus, orthophosphates, bottom deposits (dry wt-mg/kg-P)
71921	Mercury, bottom deposits (dry wt-mg/kg-Hg)

Frequency: Once per year.

Scheduling: Once every four years.

Stations to be sampled (STORET code number): 053003, 053007, 053015, 053025, 053028, 053263, 153006, 153016.

Comments: Due to high cost of analysis and slow rate of change, sediments may not need to be sampled every year.

TABLE 5F. PROPOSED FISH SAMPLING METHODS

Method

Gill net
Seine
Electroshocking
Commercial catch record

Frequency: Once per year.

Scheduling: All years.

TABLE 5G. PROPOSED BIOLOGICAL SAMPLING

Frequency:	Five times per year.
Scheduling:	Once every four years.
Comments:	Researcher should be familiar with the BIOSTORET system.

TABLE 5H. OPTIONAL SAMPLING TO MEET IJC RECOMMENDATIONS

STORET Parameter Code Number	Parameter Description
	Persistent Organic and Toxic Substances
39330	Aldrin (in whole water sample, ug/l)
39380	Dieldrin "
39350	Chlordane "
39327	O,P DDE "
39320	P,P DDE "
39315	O,P DDE "
39310	P,P DDE "
39305	O,P DDT "
39300	P,P DDT "
39390	Endrin "
39410	Heptachlor "
39420	Heptachlor epoxide "
39782	Lindane "
39480	Methoxychlor "
39400	Toxaphene "
39110	Phthalates, dibutyl "
39100	Phthalates, diethylhexyl "
39755	Mirex, total (ug/l)
39560	Diazinon (in whole water sample, ug/l)
34225	Asbestos (fibrous) (tot. w. - ug/l)
32730	Phenolics, total recoverable (ug/l)
	Metals
1045	Iron, total (ug/l as Fe)
1077	Silver, total (ug/l as Ag)
50064	Chlorine, free available (mg/l)
1105	Aluminum, total (ug/l as Al)
	Sediment
1170	Iron, bottom deposits (mg/kg as Fe dry wgt)
1078	Silver, bottom deposits (mg/kg as Ag dry wgt)
	Other
945	Sulfate, total (mg/l as SO_4)
937	Potassium, total (mg/l as k)
929	Sodium, total (mg/l as Na)
916	Calcium, total (mg/l as Ca)
927	Magnesium, total (mg/l as Mg)
955	Silica, dissolved (mg/l as SiO_2)

Frequency: Once per year.

Scheduling: Alternate years.

Stations to be sampled (STORET code number): 053003, 053007, 053015, 053025, 053028, 053263, 153006, 153016.

Comments: Addition of these parameters would allow a sampling program to meet the requirements of sampling for the International Joint Commission as of May, 1977.

SECTION 6

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APPENDIX A

COMMENTS ON BIOSTORET

Because of the problems we encountered with the BIOSTORET system, we feel that a detailed analysis of that system is appropriate as part of this report. Our comments should be useful to the people responsible for development of the system as well as future researchers who may have the opportunity to use BIOSTORET.

Implicit to the efficient use of BIOSTORET is a commitment to intensive, well organized, long term biological sampling. If an organization does not have the desires, needs or resources for such a commitment or if the implementation is not well planned, the expected returns will be limited (although possibly valuable).

Present information on BIOSTORET is of three types: 1) levels of chlorinated bi-phenyls in fish 2) nitrogen fixation rates in grab samples, and 3) taxonomic investigations of phytoplankton, benthic invertebrates, zooplankton, periphyton, and fish. Numerous concomitant variables were also processed.

Most of the biological studies date from the early 1970's and should provide a strong data base for that period. By the mid 1970's the biological community was fairly stable following the long and often rapid series of changes taking place since before 1910. This data base should be useful for showing water quality changes if comparable biological studies are done in the future. The narrow time frame in which the data was collected limits its usefulness in making general qualitative statements. The only exception to this is the benthic invertebrate data. There is a small amount of reliable data from 1952 (Surber & Cooley, 1952) for comparison to 1969-1970 data (Howmiller, 1971).

Problems with BIOSTORET are threefold: 1) data processing inefficiencies, 2) loss of information to fit it in the system and 3) reliability of canned calculations performed on the data in storage.

The data processing problems could be largely solved by the user agencies, if quality and quantity of the data justified the expense in time and money. BIOSTORET attempts to catalog the myriad of variables that affect the collection and analysis of biological samples. In cataloging these variables, the filling out of forms becomes a long and tedious process. It is unlikely a casual acquaintance with the system would be successful in storing the data correctly in a reasonable amount of time. Personnel whose primary duties lie elsewhere could not be blamed for giving BIOSTORET a low priority, especially if they have not seen appreciable returns for their efforts.

The problem could be solved by the user agency. The first step would be to scrupulously standardize field techniques. The agency could then build a program in their computer system to generate the appropriate variables for the appropriate parameters in response to keys given when the data is processed. This is a simple concept and shouldn't be difficult to someone familiar with BIOSTORET. It would make the system far more accessable to the occasional user.

The second problem is conceptual and involves minor additions to the BIOSTORET system. Taxonomy is a useful tool for cataloging systems, but may not be useful in the analysis of a system. Ecologically it may be far more important to know, for example, the larva to adult ratio of a family or order rather than the number of species A versus species B. The system should be more sensitive to variables such as life stages.

Problems also exist with the BIOSTORET taxonomic list. Spellings and taxonomic organization are incorrect and often not up to date although it is possible this type of problem is currently being corrected. Another weakness is that it is not always appropriate to pin a name from such a list on a given specimen. An immature collection could only be reliably listed as representing one of three species or a hybrid collection could not be cataloged as a species. Furthermore, the constant and rapid changes in the taxonomy of certain groups could outdate a species list shortly after it is published. An override system allowing for the use of names not on the list would be useful.

The final problem involves the use of internal BIOSTORET programs to generate desired values. The programs may greatly ease the job of the biologist by performing long, tiresome calculations with far fewer errors. Unfortunately the calculated values may be of questionable usefulness. For example, BIOSTORET produces diversity index values in Shannon-Weiner bits, but values in bits are not comparable between samples of different sizes while values in sits (base dependent on sample size) may be comparable. Users may not be aware of the difference. This problem could be avoided by making available a "blitz" program so that anyone using a data set could look at it in its entirety. Emphasis should be placed on making data arrays flexible and easy to manipulate. This would encourage user analysis in addition to automated canned programs.

APPENDIX B

DATA ENTERED ON STORET

Data is available in STORET under Agency code 21 WIS using stations and parameters noted in text. A copy of the data base is available at Great Lakes National Program Office, Chicago, Illinois.

APPENDIX C

Data Entered on BIOSTORET

Data is available in BIOSTORET under agency code 21WIS using stations and parameters listed in text. STORET USER ASSISTANCE in Washington, D.C. 202-426-7792 should be contacted for data retrieval instruction.

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16. ABSTRACT

Research with quantitative water quality data from Green Bay was located and evaluated by objective criteria. Data from "high priority" studies were entered into Environmental Protection Agency computer systems (chemical data in STORET and biological data in BIOSTORET). A summary of the data stored is presented.

Using this data base, changes in Green Bay water quality were examined, but made difficult by deficiencies and inconsistencies in the different researchers' sampling locations, frequencies and methods. A sampling network is proposed that would correct the deficiencies and efficiently monitor water quality conditions in Green Bay.

The data stored in the computer systems and the proposed sampling network provide background information for future research on Green Bay water quality.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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